Geotechnical Evaluation Report

Broadway at Center Parking Ramp
Block 33, Lots 1-6 (Original Platte of Rochester)
Rochester, Minnesota

Prepared for

Titan Development and Investments

Professional Certification:
I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Ray A. Huber, PE
Vice President / Principal Engineer
License Number: 15329
March 14, 2014

Project RO-13-08144B

Braun Intertec Corporation

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March 14, 2014

Project RO-13-08144B

Darren Schlapkohl
VP Development & Construction Management
Titan Development and Investments
221 1st Avenue SW, Suite 300
Rochester, MN 55902

Re: Geotechnical Evaluation
Broadway at Center Parking Ramp
Block 33, Lots 1-6 (Original Platte of Rochester)
Rochester, Minnesota

Dear Mr. Schlapkohl:

We are pleased to present this Geotechnical Evaluation Report for the proposed Broadway at Center Parking Ramp project in Rochester, Minnesota. A summary of our results, and a summary of our recommendations in light of the geotechnical issues influencing design and construction is presented below. More detailed information and recommendations follow.

Summary of Results

Our borings initially encountered 3 inches of bituminous pavement over uncontrolled fill that extended to depths ranging from approximately 3 to 11 feet below the ground surface. Portions of the fill appeared to contain debris including coal slag. Based on results of our penetration resistance testing, the uncontrolled fill appears to be variably compacted.

Below the pavement materials and uncontrolled fill, our borings generally encountered alluvial sands that extended to the bedrock surface at depth. Penetration resistance values recorded in the alluvial sands indicated they were locally loose to dense but medium dense to dense overall.

All of the borings met refusal in Shakopee Formation bedrock at depths ranging from approximately 8 to 26½ feet. Based on our examination of the current borings and the previous geotechnical evaluations near the site, we anticipate bedrock depths ranging from 6 feet at the southwest corner of the site to 23 near the east-central portion of the site.

The rock cores extended into the bedrock revealed interbedded sandy dolostone and sandstone with thin layers of shale, chert nodules, and calcite nodules. Our findings suggest that the Shakopee Formation below the site is highly weathered with areas of significantly decomposed sandy dolostone that could be associated with fissures and joints within the formation.

Groundwater was observed at a depth of approximately 21 feet below the ground surface, 3 days after setting the temporary well in Boring ST-2. This depth corresponds to an approximate elevation of 975 feet. This groundwater elevation correlates with the findings of our 2014 draft geotechnical evaluation for the Broadway at Center site, as well as our historical knowledge of the long-term groundwater levels in the downtown Rochester area.

Summary of Recommendations

Excavations and Subgrade Preparation

We recommend removing the pavement materials and existing fill from below the ramp foundations and slabs. Depending on their location and elevation in relation to the bedrock surface, foundations can then be supported on alluvial sands or bedrock. Foundation design for spread footings bearing on the alluvial sands will need to account for a lower bearing capacity than those bearing on bedrock to control settlement.

The design team should be aware that the allowable bearing capacity provided below for foundations bearing on bedrock assumes that all weathered bedrock removable with an excavator equipped with a toothed bucket has been removed from below the footings. Footings bearing on decomposed and intensely fractured bedrock strata (roughly characterized as those strata penetrable by a hollow-stem auger) should be designed based on the bearing capacity recommendation for alluvial sands.

If spread foundations in areas not immediately adjacent to the rail line will bear on minimal thicknesses of alluvial sands or decomposed bedrock above the “competent” bedrock surface, the design team should be prepared to lower foundation bearing elevations to optimize the foundation design. Braun Intertec personnel should be on site during excavation to evaluate foundation subgrade conditions in relation to those assumed for design at each column location.

As an alternative to designing for lower allowable bearing capacities or modifying foundation bearing elevations in the alluvial sand and decomposed bedrock strata, the design team could also consider installing drilled piers to transfer loads to more “competent” rock at depth.

If areas of significantly decomposed bedrock extending below footing elevations are encountered during excavation, some localized removal and replacement with concrete may be required. Bedrock excavations should be observed by a geotechnical engineer to determine if, and to what extent, local fractures or decomposed portions of the bedrock will require removal and replacement.

Spread Footings

Based on our calculations and past project experience with Shakopee Formation bedrock, we recommend sizing spread footings bearing on bedrock to exert a net allowable bearing pressure of 25 tons per square foot (tsf), including all transient loads. This value includes a safety factor of at least 3.0 with regard to bearing capacity failure.

We recommend sizing spread footings bearing on alluvial sands or decomposed bedrock to exert a net allowable bearing pressure of 10,000 pounds per square foot (psf), including all transient loads. This value includes a safety factor of at least 3.0 with regard to bearing capacity failure.
If spread foundations are placed on a combination of bedrock and alluvial sands, we estimate that differential settlements among the footings could approach ¾ inch under the reported loads. However, if all column pads are extended to “competent” rock, or if the ramp is supported on a combination of

spread footings and drilled piers extended to "competent" rock, we estimate total and differential settlements among the footings will amount to less than ¼ inch in both cases.

We anticipate differential settlements between the subway levels of the Broadway at Center tower and the parking ramp will amount to less than ½ inch, but we do recommend installing expansion joints between the two structures to accommodate differential settlements.

Subway Level Slabs

For constructability and to limit cracking of the slabs, we recommend subcutting bedrock below the subway level floor slab a minimum of 12 inches. Slab subgrades should them be backfilled with coarse sand or having less than 50 percent of the particles by weight passing a #40 sieve and less than 5 percent of the particles passing a #200 sieve.

We also recommend installing a subgrade drainage system below the subway level floor slab to reduce the potential for groundwater infiltration during Zumbro River flood events.

Below-Grade Walls

We recommend installing subdrains adjacent to the wall footings, below the slab elevation. We recommend routing the subdrains to a sump and pump capable of routing any accumulated groundwater to a storm sewer or other suitable disposal site.

General damp-proofing of all below-grade walls is recommended. In addition, we recommend waterproofing the section of the elevator shaft extending below the finished floor elevation of the parking area.

Unless a drainage composite is placed against the backs of the exterior perimeter below-grade walls, we recommend that backfill placed within 2 horizontal feet of those walls consist of sand having less than 50 percent of the particles by weight passing a #40 sieve and less than 5 percent of the particles by weight passing a #200 sieve.

Pavements

We recommend stripping all existing pavements and surface compacting the exposed subgrades with a large vibratory sheepsfoot compactor prior to placement of the base section. On-site soils free of organic soil and debris can be considered for placement up to design subgrade elevations in pavement areas. Imported fill placed below pavement subgrades should consist of sand having less than 20 percent of the particles by weight passing a #200 sieve.

Prior to placing aggregate base material, we recommend proofrolling pavement subgrades to determine if the subgrade materials are loose, soft or weak, and in need of further stabilization, compaction or subexcavation and recompaction or replacement.

We recommend a bituminous pavement section that includes 4 inches of bituminous pavement (a 2-inch surface course over a 2-inch base course) over 6 inches of aggregate base material. Where concrete pavements will be utilized, we recommend a section that includes 6 inches of concrete slab over least 4 inches of aggregate base.

Remarks

Thank you for making Braun Intertec your geotechnical consultant for this project. If you have questions about this report, or if there are other services that we can provide in support of our work to date, please contact Tyler Niemeyer at 507.281.2515 or Ray Huber at 952.995.2260.

Sincerely,

BRAUN INTERTEC CORPORATION

Tyler S. Niemeyer, PE
Project Engineer

Ray A. Huber, PE
Vice President / Principal Engineer

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A. Introduction

A.1. Project Description

This Geotechnical Evaluation Report addresses the proposed construction of the Broadway at Center Parking Ramp immediately east of the proposed Broadway at Center Tower and Broadway Plaza in Rochester, Minnesota. Based on the information provided by the design team, we understand this project includes construction of an 8-story, unheated, post-tensioned concrete parking ramp. The ramp will have a subway level, where it will tie-into the proposed Broadway at Center tower approximately 11½ feet below current site grades. The parking ramp is to be designed for column service loads ranging from 980 kips for the exterior columns to 2050 kips for interior columns near the loading dock area.

A.2. Purpose

The purpose of this geotechnical evaluation is to characterize subsurface geologic conditions at the selected exploration locations and evaluate their impact on the design and construction of the proposed parking ramp.

A.3. Background Information and Reference Documents

To facilitate our evaluation, we were provided with or reviewed the following information or documents:

- Preliminary architectural renderings of the parking ramp, prepared by Albersman and Armstrong, Ltd., dated February 12, 2014.
- Discussions with HGA on February 18, 2014 regarding the proposed structural layout and approximate finished floor elevations for the facility.
- American Engineering Testing (AET) Geotechnical Report Number 11-00526, dated July 20, 1999.
- Yaggy Colby Associates (YCA) Geotechnical Report for the Broadway Plaza site, dated January 30, 2001.
- Braun Intertec Geotechnical Report BCDX-01-142 for the Broadway Plaza site, dated February 11, 2002.
- Braun Intertec DRAFT Geotechnical Report RO-13-08144 for the Broadway at Center site, dated January 21, 2014.

- Minnesota Geological Survey atlases prepared by Olsen and Hobbs in 1988, describing the surficial and bedrock geology of Olmsted County.

A.4. Site Conditions

Currently, the site exists as a City-owned at-grade parking lot surfaced with bituminous pavement. The proposed ramp footprint also contains a concrete-surfaced City-owned alley, landscaped areas, and sidewalks. Surficial site soils have likely been impacted by demolition of previous buildings and construction of the existing alley and parking lot.

Based on our review of the sources cited above, construction will likely be impacted by several conditions including previous development and demolition in the area, a variety of soil types, shallow bedrock, and groundwater.

A.5. Scope of Services

Our scope of services for this project was originally submitted as a proposal to Mr. Mark Steege of Titan Development and Investments on January 10, 2014. We later received authorization to proceed from Mr. Steege shortly thereafter. Tasks completed in accordance with our authorized scope of services are described below.

A.5.a. Reconnaissance

We performed a reconnaissance of the site primarily to evaluate equipment access to exploration locations. We also observed and took notes regarding parking and site access arrangements.

A.5.b. Staking and Surveying

The standard penetration test boring locations and surface elevations at these locations were determined using GPS (Global Positioning System) technology that utilizes the Olmsted County Coordinates which are based on NGVD datum.

A.5.c. Subsurface Exploration

We performed 8 standard penetration test borings for the parking ramp (ST-14 through ST-22) at the locations shown on the Boring Location sketch in the Appendix. The borings were extended to refusal on bedrock. We also installed a temporary monitoring well at Boring ST-22 and measured the groundwater level at this location 3 days after well installation.

Two rock cores were taken from below the depths at which Borings ST-18 and ST-22 met refusal on bedrock. The cores were advanced approximately 7½ to 10 feet below auger refusal.

Prior to commencing with our subsurface exploration activities, we cleared the exploration locations of underground utilities through Gopher State One Call.

A.5.d. Environmental Screening

An environmental investigation was completed in conjunction with this geotechnical evaluation. As part of the environmental investigation, soil and groundwater samples were collected, and the soil borings were examined by an environmental technician for unusual staining, odors, and other apparent signs of contamination. In addition, the soil samples were screened for the presence of organic vapors using a photoionization detector (PID). The PID was equipped with a 10.6-electron-volt lamp and calibrated to an isobutylene standard. The PID was used to perform a headspace method of analyses, as recommended by the Minnesota Pollution Control Agency (MPCA). PID results are included on the attached boring logs. For a complete summary of environmental conditions, please refer to the following report that was provided separate cover: *Environmental Investigation; Broadway at Center; South Broadway Avenue and East Center Street; Rochester, Minnesota*; prepared by Braun Intertec, dated February 24, 2014.

A.5.e. Geotechnical Evaluation, Analysis and Reporting

Information obtained from the borings was used to identify the geotechnical issues influencing design and construction, qualify the nature of their impact, and outline alternatives for their mitigation. Upon reviewing our results, we developed baseline recommendations for:

- General site preparation.
- Groundwater control during construction and for the permanent facility.
- Preparing structure subgrades, including excavation support, and the selection, placement and compaction of excavation backfill and other structural fill.
- Design net bearing values, modulus of subgrade reaction, coefficient of sliding friction, and foundation design alternatives.
- The design of spread footings for each loading condition, including design criteria used to develop the recommendations.
- Lateral earth pressure design values for basement walls and temporary retention systems.
- Providing quality control and evaluating differing site conditions during construction.

B. Results

B.1. Exploration Logs

B.1.a. Log of Boring Sheets

Log of Boring sheets for our penetration test borings are included in the Appendix. The logs identify and describe the geologic materials that were penetrated, and, where applicable, present the results of penetration resistance tests performed within them, organic vapor screening, and groundwater measurements.

Strata boundaries were inferred from changes in the penetration test samples and the auger cuttings. Because sampling was not performed continuously, the strata boundary depths are only approximate. The boundary depths likely vary away from the boring locations, and the boundaries themselves may also occur as gradual rather than abrupt transitions.

B.1.b. Log of Coring Sheets

Log of Coring sheets follow the logs of the penetration test borings through which the cores were taken. The logs identify and describe rock lithology, weathering, hardness, bedding and fracture characteristics, and other features. The logs also report the results of bit pressure, rate of advance, and water pressure and return (if applicable) recorded during the coring process. The percent recovery and rock quality designation (RQD) for each core run is also shown.

Strata boundaries were inferred from changes in lithology along the length of the core sample. Because natural and mechanical fractures, destruction of the rock fabric during coring, and limited recovery make it difficult to accurately place the core sample in the geologic profile, the strata boundary depths are here, too, only approximate, and likely vary away from the core locations.

B.1.c. Geologic Origins

Geologic origins assigned to the materials shown on the logs and referenced within this report were based on: (1) a review of the background information and reference documents cited above, (2) visual classification of the various geologic material samples retrieved during the course of our subsurface exploration, (3) penetration resistance testing performed for the project, (4) laboratory test results, and (5) available common knowledge of the geologic processes and environments that have impacted the site and surrounding area in the past.

B.2. Geologic Profile

As revealed by the borings, the site is underlain with a variety of materials existing pavements, uncontrolled fill, alluvial sands, and bedrock.

B.2.a. Pavement Materials and Uncontrolled Fill

The borings initially encountered approximately 3 inches of bituminous pavement over uncontrolled fill. The uncontrolled fill extended to depths ranging from approximately 3 to 11 feet below the ground surface. The fill consisted of clayey gravel (GC), clayey sand (SC), silty sand (SM), poorly graded sand with silt (SP-SM), and poorly graded sand (SP) that was light brown to black in color and frozen or moist. Portions of the fill also appeared to contain debris including coal slag.

Penetration resistance values recorded in the uncontrolled fill ranged from 18 blows per foot (BPF) to 50 blows for 6 inches of penetration, indicating these soils are variably compacted. We also recorded penetration resistance values ranging from 50 to 123 BPF in the uncontrolled fill present in the upper 5 feet of the subsurface profile, but these blow counts were affected by frost.

B.2.b. Alluvial Deposits

Below the pavement materials and uncontrolled fill, our borings generally encountered alluvial sands consisting of poorly graded sand, poorly graded sand with silt, silty sand, and clayey sand. These soils were light brown to dark brown in color and moist to waterbearing.

Penetration resistance values recorded in the alluvial sands ranged from 6 to 36 BPF, but generally exceeded 12 BPF, indicating they were locally loose to dense but medium dense to dense overall. We also recorded penetration resistance values ranging from 52 to 70 BPF in the alluvial sands present in the upper 5 feet of the subsurface profile, but these blow counts were affected by frost.

B.2.c. Bedrock

We assume all of the borings that met refusal were terminated in Shakopee Formation bedrock, however, boring locations that did not include rock coring may have encountered refusal on cobbles, boulders, or bedrock floats. In general, our borings first encountered weathered Shakopee Formation bedrock at depths ranging from approximately 6 to 24 feet. In some areas, our hollow-stem auger was able to extend ½ to 10½ feet into the bedrock, indicating a variable and highly weathered bedrock surface. Hollow-stem auger refusal depths ranged from 8 feet in the southwest portion of the site to 26½ feet near the east-central portion of the site.

The rock cores extended into the bedrock revealed interbedded sandy dolostone and sandstone with thin layers of shale, chert nodules, and calcite nodules. Our findings suggest that the Shakopee Formation below the site is highly weathered with areas of significantly decomposed sandy dolostone that could be associated with fissures and joints within the formation.

As reported on the Log of Coring sheets, core recovery in the bedrock cored in Borings ST-18 and ST-22 ranged from 37 to 100 percent; the rock was decomposed to moderately weathered, intensely to moderately fractured, with RQD's ranging from 0 to 87 percent.

Voids were not noted during drilling or coring operations, but it should be noted that cavernous rock has previously been encountered in the Shakopee Formation in the downtown Rochester area.

B.2.d. Bedrock Elevations

Table 1 below summarizes the depths and corresponding elevations at which bedrock was encountered in our borings. Borings performed within the proposed ramp footprint for the previous investigations cited above have also been included.

Table 1. Bedrock Elevations

Boring Number	Surface Elevation	Location Description	Weathered Bedrock Surface		Auger Refusal*	
			Depth (ft)	Elevation	Depth (ft)	Elevation
ST-14	995.4	See attached sketch	10	985½	16½	979
ST-15	995.4	See attached sketch	--	--	24	971½
ST-16	994.8	See attached sketch	14	981	24½	970½
ST-17	996.2	See attached sketch	19	977	19½	976½
ST-18	995.2	See attached sketch	23	972	26½	969
ST-19	996.1	See attached sketch	9	987	11	985
ST-20	995.6	See attached sketch	10	985½	20½	975½
ST-21	997.0	See attached sketch	6	991	8	989
ST-22	996.1	See attached sketch	11	985	14	982½

*Note: We have assumed the borings that met refusal were terminated in the Shakopee Formation in all areas, but this could not be confirmed in every case.

B.2.e. Hydrological Soil Group

The uncontrolled fill generally falls under Minnesota Stormwater Manual Hydrologic Soil Group B, while the alluvial sands are considered Group A soils.

B.2.f. Groundwater

Groundwater was observed at a depth of approximately 21 feet below the ground surface, 3 days after setting the temporary well in Boring ST-2. This depth corresponds to an approximate elevation of 975 feet. This groundwater elevation correlates with the findings of our 2014 draft geotechnical evaluation for the Broadway at Center site, as well as our historical knowledge of the long-term groundwater levels in the downtown Rochester area. Fluctuations of groundwater levels correlating to seasonal and annual oscillations in levels of the nearby Zumbro River should be anticipated.

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) (Map No. 27109C0164 E, revised February 4, 1998), the base flood elevations for the sections of the river closest to the project site range from 983 to 984 feet (to the east) to 987 feet (to the southeast). According to the same source, current surface grades at the site are outside the 500-year floodplain of the Zumbro River.

C. Basis for Recommendations

C.1. Design Details

C.1.a. Ramp Structure Loads

The information provided by HGA estimates column service loads ranging from 980 kips for the exterior columns to 2050 kips for interior columns near the loading dock area.

C.1.b. Pavements and Traffic Loads

HGA has requested recommendations for pavement sections for potential parking areas and service drives. We understand both bituminous and concrete sections will be considered for pavement areas. We have assumed that pavements will be subjected to no more than 75,000 equivalent 18-kip single axle loads (ESALs) over an assumed design life of 20 years, with minimal traffic from delivery and heavy trucks.

C.1.c. Anticipated Ramp Elevations

Based on the information provided by the design team, we understand this project includes construction of an 8-story post-tensioned concrete parking ramp. The ramp will have a subway level, where it will tie-into the proposed Broadway at Center tower approximately 11½ feet below current site grades. For the purposes of this report, we have assumed a slab elevation of approximately 983½ feet (MSL). Based on this finished floor elevation and the fact that the parking ramp will be unheated, we have assumed bottom of footing elevations will be no higher than 978½ feet.

C.1.d. Precautions Regarding Changed Information

We have attempted to describe our understanding of the proposed construction to the extent it was reported to us by others. Depending on the extent of available information, assumptions may have been made based on our experience with similar projects. If we have not correctly recorded or interpreted the project details, we should be notified. New or changed information could require additional evaluation, analyses and/or recommendations.

C.2. Design and Construction Considerations

We anticipate excavations for the subway level of the ramp will require installation of temporary retention system at the perimeter of the ramp footprint. The DM&E rail line located along the east edge of the site introduces the potential for relatively large surcharge loads and dynamic loads on the temporary retention system. Limiting excavation depths along the rail line will help to reduce the magnitude of the forces to be counteracted by the temporary retention system.

Spread foundations bearing on the bedrock generally appear to be the most economical foundation system for the parking ramp, but limiting excavation depths along the rail line will likely force foundation elevations above the bedrock surface and into the alluvial sand stratum. Foundation design for spread footings bearing on the alluvial sands will need to account for a lower bearing capacity than those bearing on bedrock. The design team could also consider installing drilled piers along the rail line (instead of excavating frost-depth footings below the subway level slab) as a way to minimize excavation depths in this area.

Based on the anticipated footing elevations, portions of the footing excavations will extend 10 feet or more into bedrock. The design team and contractor should be aware that the elevation and condition of the bedrock surface is likely inconsistent and may require a variety of excavation methods. The upper portions of the bedrock are decomposed and sections of the bedrock can likely be dislodged and removed using large dozers equipped with ripping teeth or large backhoes equipped with toothed buckets. Removal of the remaining bedrock present within the anticipated excavation depths will likely require pneumatic hammers.

Groundwater was observed at an elevation of approximately 975 feet in the temporary well installed during our field investigation. Given the anticipated footing excavation depth of 978½, footing excavations will likely fall above the long-term groundwater elevation. Depending on design, however, excavations for elevator pits may approach the groundwater surface. If groundwater seepage in the alluvial sands cannot be controlled with sumps and pumps, or if upward seepage begins to loosen or disturb the excavation bottom, the contractor may need to use well points to draw groundwater down at least 2 feet below the anticipated excavation bottom.

Given the ramp's proximity to the Zumbro River and the potential for high groundwater levels during river flood events, waterproofing is recommended for any elevator pits extending below the finished floor elevation of the parking area (983½ feet).

If the uncontrolled fill and alluvial sands do not meet the gradation requirements outlined in Section D.2, sands or gravels will have to be imported to facilitate drainage behind below-grade walls and below the subway level slab.

Portions uncontrolled fill at anticipated exterior slab subgrade elevations appear to be rich in silt and clay. Due to the frost susceptible nature of these soils, consideration should be given to incorporating a granular subbase into the exterior flat work. A granular subbase enhances subgrade drainage, reduces the potential for subgrades to become saturated and heave upon freezing, and reduces the effects of subgrade strength loss upon thawing.

D. Recommendations

In accordance with our findings and discussions with HGA, below are our recommendations for excavation and subgrade preparation, selection and compaction of backfill and fill, spread footings, drilled piers, subway level slabs, below-grade walls, exterior slabs, pavements, frost protection, utilities, and construction quality control.

D.1. Excavation and Subgrade Preparation

We recommend removing the pavement materials and existing fill from below the ramp foundations and slabs. Depending on their location and elevation in relation to the bedrock surface, foundations can then be supported on alluvial sands or bedrock. Foundation design for spread footings bearing on the alluvial sands will need to account for a lower bearing capacity than those bearing on bedrock to control settlement.

The design team should be aware that the allowable bearing capacity provided below for foundations bearing on bedrock assumes that all weathered bedrock removable with an excavator equipped with a toothed bucket has been removed from below the footings. Footings bearing on decomposed and intensely fractured bedrock strata (roughly characterized as those strata penetrable by a hollow-stem auger) should be designed based on the bearing capacity recommendation for alluvial sands.

As an alternative to designing for lower allowable bearing capacities or modifying foundation bearing elevations in the alluvial sand and decomposed bedrock strata, the design team could also consider installing drilled piers to transfer loads to more “competent” rock at depth.

We recommend a geotechnical engineer be on site to evaluate the bedrock at foundation subgrades and excavation bottoms during excavation operations. To aid in bedrock evaluation, we recommend extending probe holes a minimum of 5 feet below top-of-rock elevation or foundation subgrades (whichever is deeper). We recommend a minimum frequency of one probe hole per 10 column foundations, with the option to add additional probe hole locations at the discretion of the geotechnical engineer. If areas of significantly decomposed bedrock extending below footing elevations are encountered during excavation, some localized removal and replacement with concrete may be required.

D.1.a. Excavation Support

The existing fill and alluvial sands are Type C Soils under OSHA guidelines. Unsupported excavations in these soils should therefore be maintained at a gradient no steeper than 1½:1 (horizontal:vertical). Site constraints and anticipated excavation depths will, however, necessitate temporary retention during construction. The temporary retention system should extend through the soils and highly weathered bedrock, but can be discontinued in stable bedrock (bedrock that can maintain a nearly vertical gradient without shoring).

We recommend designing the temporary retention system based on the parameters presented below in Table 2. The parameters shown are for soils above the bedrock surface, as we have assumed the temporary retention system will not extend below the top of stable bedrock. The parameters have not been reduced by safety factors.

Table 2. Retention System Lateral Pressures

Geologic Material	Classification	Wet Unit Weight (pcf)	Friction Angle (deg)	K_A	K_O	K_P
Existing Fill	SC, GC, SM, SP-SM, SP	130	26	0.39	0.56	2.6
Alluvial Sands	SP, SP-SM	120	35	0.27	0.43	3.7

As noted above, the DM&E rail line located along the east edge of the site introduces the potential for relatively large surcharge loads and dynamic loads on the temporary retention system.

Limiting excavation depths along the rail line will help to reduce the magnitude of the forces to be counteracted by the temporary retention system, but tiebacks may still be required to support loads introduced by train traffic. We recommend discussing potential temporary retention systems with DM&E and engineers experienced in temporary retention design before evaluating any temporary retention systems that could encroach on the rail right-of-way.

Based on the subsurface profile of the site, the following options would be feasible for retaining the soil profile above the bedrock.

- Grouting H-piles approximately 2-feet into cored holes in stable bedrock and extending the piles to the ground surface. With this alternative, the H-piles would be tied-back to the bedrock at ⅔ the height of the piles, with whalers extending between the tie-back anchors and wood lagging installed between the H-piles. The H-piles would need to be set-back approximately 1-2 feet from the vertical rock face to provide toe resistance for the piles. We recommend a grout-to-bedrock adhesion value of 150 psi for pull-out resistance of the tie back anchors. This value can be increased if on-site load tests confirm a higher adhesion value. This option would, however, encroach on the rail right-of-way.
- Installing a cantilevered pile system by grouting H-piles approximately 5 to 8 feet into cored holes in the stable bedrock and extending the piles to the ground surface. The piles would be tied together with wood lagging, but no tieback anchors would be required, as pressures exerted on the walls would be resisted by the sections of the piles grouted into the bedrock. The H-piles would need to be set-back approximately 3-4 feet from the vertical rock face to resist overturning pressures on the piles. The additional setback distance may introduce additional cost due to the increased size of the excavation and additional required wall backfill. Those designing the temporary retention system should also evaluate if structures within the active zones of the walls can tolerate rotation of a cantilevered system. If the cantilevered system introduces risk to adjacent structures, tie-backs (as detailed in the option above) may be required to reduce rotation of the wall.

Other earth retention systems my also be feasible and cost effective. The design team and contractor should examine all possible retention systems prior to selection of the system used during construction.

D.1.b. Excavation Dewatering

As noted above, groundwater was observed at an elevation of approximately 975 feet in the temporary well installed during our field investigation. Given the anticipated footing excavation depth of 978.5, footing excavations will likely fall above the long-term groundwater elevation. Excavations could, however, encounter groundwater perched above the long-term groundwater elevation near the bedrock surface or within sandstone seams in the Shakopee Formation. In addition, excavations for elevator pits may approach the groundwater surface. If groundwater enters the excavation, dewatering will be required to facilitate construction and to allow for evaluation of the geologic materials exposed in the excavations. We recommend excavating sump locations at the bottom of the excavation to allow for accumulation of groundwater and removal with pumps routed to a storm sewer or other suitable disposal site.

The contractor should also be prepared for fluctuations of groundwater levels correlating to seasonal and annual oscillations in levels of the nearby Zumbro River. Based on our research, the flood-stage surface elevation of the Zumbro River near the site is 987 feet. Groundwater seepage through the soil, bedrock fractures, and sandstone layers will likely vary across the site, but the contractor should be prepared to mitigate significant entrance of groundwater into the excavation during a flood event.

D.2. Selection and Compaction of Backfill and Fill

We recommend backfilling below-grade walls and slab subgrades with sand having less than 30 percent of the particles by weight passing a #40 sieve, and less than 10 percent of the particles passing a #200 sieve. If the on-site alluvial sands do not meet these gradation requirements, or if additional fill is required to backfill the balance of below-grade wall excavations, this material will need to be imported.

We recommend spreading backfill and fill in loose lifts of approximately 12 inches. We recommend compacting backfill and fill in accordance with the criteria presented below in Table 3. The relative compaction of utility backfill should be evaluated based on the structure below which it is installed, and vertical proximity to that structure.

Table 3. Compaction Recommendations Summary

Reference	Relative Compaction, percent (ASTM D 698 – standard Proctor)	Moisture Content Variance from Optimum, percentage points
Below the subway level slab	95	+/- 3%
Below isolated footings for at-grade canopies or stoops	100	
Below exterior slabs	95	
Below landscaped surfaces	90	+/- 5%

D.3. Spread Footings

D.3.a. Embedment Depth

We understand the parking ramp will be unheated. We therefore, recommend embedding footings 60 inches below slab elevation on the subway level.

D.3.b. Net Allowable Bearing Pressure (Bedrock)

Based on our calculations and past project experience with Shakopee Formation bedrock, we recommend sizing spread footings bearing on bedrock to exert a net allowable bearing pressure of 25 tons per square foot (tsf), including all transient loads. This value includes a safety factor of at least 3.0 with regard to bearing capacity failure.

D.3.c. Net Allowable Bearing Pressure (Alluvial Sands and Decomposed Bedrock)

We recommend sizing spread footings bearing on alluvial sands or decomposed bedrock to exert a net allowable bearing pressure of 10,000 pounds per square foot (psf), including all transient loads. This value includes a safety factor of at least 3.0 with regard to bearing capacity failure.

D.3.d. Settlement

If spread foundations are placed on a combination of bedrock and alluvial sands, we estimate that differential settlements among the footings could approach ¾ inch under the reported loads. However, if all column pads are extended to “competent” rock, or if the ramp is supported on a combination of spread footings and drilled piers extended to “competent” rock, we estimate total and differential settlements among the footings will amount to less than ¼ inch in both cases.

We anticipate differential settlements between the subway levels of the Broadway at Center tower and the parking ramp will amount to less than ½ inch, but we do recommend installing expansion joints between the two structures to accommodate differential settlements.

D.3.e. Resisting Uplift/Overturning

If the structural design requires additional resistance to resisting uplift and overturning, we recommend installing rock anchors or drilled piers in the bedrock. We recommend a grout-to-bedrock adhesion value of 150 psi for pull-out resistance of the tie back anchors or drilled piers. This value can be increased if on-site load tests confirm a higher adhesion value.

D.4. Drilled Piers

As noted above, drilled piers extended to “competent” bedrock are one alternate to minimize excavation depths along the rail line and eliminate the need to design for lower allowable bearing capacities or modified foundation bearing elevations in the alluvial sand and decomposed bedrock strata.

D.4.a. Allowable Bearing Capacities

Based on our analysis, we recommend that piers supported on the bedrock be sized to exert a net allowable bearing pressure of 25 tsf. As with spread foundations, this allowable bearing capacity assumes that the piers are advanced through decomposed and highly fractured bedrock to the more “competent” bedrock at depth. Braun Intertec personnel should be on site during drilling of the shafts to observe bedrock conditions and verify that design end-bearing elevations of the piers fall in rock suitable for support of the design loads.

D.4.b. Drilled Shaft Support

We anticipate that the pier shafts will need to be cased through the alluvial sands and decomposed bedrock strata to prevent caving. Telescoping casings may be required for longer shafts. With telescoping casings, the largest casing is set at the top of the shaft, and subsequent casings becoming progressively smaller with the smallest casing having a diameter equal to the design diameter of the pier. To help accommodate telescoping casings for this project, we recommend assuming a 6-inch increase in diameter per casing.

D.4.c. Concrete Placement

It is possible to pull telescoping casing in such a way as to construct the drilled pier at its design diameter for its entire length. This practice, however, risks leaving loose material against the pier and effectively reducing confinement offered to the pier. To avoid problems associated with this situation, we recommend that the concrete be placed to the full diameter of the drilled shaft.

If, prior to placing concrete, more than 2 inches of uncontaminated groundwater is present in the shaft, we recommend installing a sump and pump to remove the excess water. Alternatively, the concrete can be placed with a tremie pipe, although the concrete should then be designed for a slump between approximately 4 and 6 inches.

D.4.d. Obstructions

As the shafts for the piers are drilled, obstructions may be encountered that cannot be removed with conventional drilling equipment. In our opinion, an obstruction can be considered to consist of a dense concentration of cobbles, boulders, detached rock slabs or other material, natural or man-made, that impedes drilling with conventional augers and requires special equipment including but not necessarily limited to, core barrels, air compressors, or hand excavation tools to penetrate. The obstruction can be considered to have been penetrated once conventional augering can resume.

The presence of in-place rock which must be removed with special equipment in order to attain required embedments does not, in our opinion, qualify as an obstruction, but should instead be considered to fall under the category of rock removal.

D.5. Subway Level Slabs

D.5.a. Subgrade Preparation/Drainage

For constructability and to limit cracking of the slabs, we recommend subcutting bedrock below the subway level floor slab a minimum of 12 inches. Slab subgrades should them be backfilled with coarse sand or having less than 30 percent of the particles by weight passing a #40 sieve and less than 10 percent of the particles passing a #200 sieve.

Based on our research, the Zumbro River located southeast of the site has a base flood-stage elevation of 987 feet and groundwater levels could rise above the subway level slab elevation during flood events. We, therefore, also recommend installing a subgrade drainage system below the subway level floor slab to reduce the potential for groundwater infiltration during Zumbro River flood events. A subdrain grid consisting of perforated pipes wrapped in filter fabric should be installed in the sand subgrade section at an approximate spacing of 50 feet in each direction. The subdrains should be routed to a sump and pump capable of routing any seepage to a storm sewer or other suitable disposal site.

D.5.b. Subgrade Modulus

We recommend using a modulus of subgrade reaction, k, of 200 pounds per square inch per inch of deflection (pci) to design the subway level floor slabs.

D.5.c. Moisture Vapor Protection

Excess transmission of water vapor could cause floor dampness. If moisture is a concern, consideration should be given to placing a vapor retarder or vapor barrier below slabs.

If installed, we recommend placing the vapor retarder or barrier directly below the concrete. To help limit concrete shrinkage and curling, we also recommend:

- Using the largest maximum aggregate size and/or coarse aggregate as possible.
- Using the lowest practical slump and limiting the use of retempering water.
- Using the lowest necessary cement content to reduce top-to-bottom moisture differentials.
- Carefully curing the concrete.
- Optimizing the spacing of control joints.
- Cutting control joints as soon as practical.

Current practices often allow the vapor retarder or barrier to be buried below a layer of sand to reduce concrete shrinkage and curling. Those practices, however, risk trapping water between the slabs and the vapor retarder or barrier, and causing moisture vapor problems some time after construction. If the vapor retarder or barrier is buried below a layer of sand, consideration should be given to:

- Eliminating moisture-trapping slip sheets, where possible, from below the slabs.
- Installing roof drains prior to vapor retarder or barrier installation to reduce wetting of the sand cushion.
- Directing the concrete subcontractor to keep excess process water away from the sand cushion.
- Sealing control joints to discourage water from penetrating the slabs after construction.

If installed, we recommend that the vapor retarder or barrier be observed prior to concrete or sand placement so that holes, tears or gaps in the vapor retarder or barrier can be identified and patched or realigned as needed.

D.6. Below-Grade Walls

The following recommendations should be used to design walls backfilled with soil. This will include below-grade walls above the bedrock surface, and walls for which excavations in bedrock are adequately oversized to allow for compaction of wall backfill. Depending on the amount of backfill placed between the bedrock face and the below-grade walls, the design team may be able to reduce lateral pressures after accounting for the effects of soil arching.

If the walls below the bedrock surface will be formed at their exterior by the vertical face of the bedrock excavation, lateral pressures on the walls will be minimal.

D.6.a. Drainage Control

We recommend installing subdrains adjacent to the wall footings, below the slab elevation. Preferably the subdrains should consist of perforated pipes embedded in washed gravel, which in turn is wrapped in filter fabric. Perforated pipes encased in a filter "sock" and embedded in washed gravel, however, may also be considered.

We recommend routing the subdrains to a sump and pump capable of routing any accumulated groundwater to a storm sewer or other suitable disposal site.

General damp-proofing of all below-grade walls is recommended. In addition, we recommend waterproofing the section of the elevator shaft extending below the finished floor elevation of the parking area.

D.6.b. Selection, Placement and Compaction of Backfill

Unless a drainage composite is placed against the backs of the exterior perimeter below-grade walls, we recommend that backfill placed within 2 horizontal feet of those walls consist of sand having less than 50 percent of the particles by weight passing a #40 sieve and less than 5 percent of the particles by weight passing a #200 sieve. Sand meeting this gradation will likely need to be imported.

We recommend a walk behind compactor be used to compact the backfill placed within about 5 feet of the retaining walls. Further away than that, a self-propelled compactor can be used. Compaction criteria for below-grade walls should be determined based on the compaction recommendations provided above in Section D.2.

Exterior backfill not capped with exterior slabs should be capped with a low-permeability soil to limit the infiltration of surface drainage into the backfill. The finished surface should also be sloped to divert water away from the walls.

D.6.c. Configuring and Resisting Lateral Loads

We have assumed rotation of the below-grade walls cannot be tolerated, and below-grade wall design will be based on at-rest earth pressure conditions. Based on this assumption, we recommend designing for an equivalent fluid pressure of 50 pcf.

Our recommended design values are based on a wet unit backfill weight for sand of 120 pcf, an internal friction angle of 35 degrees, and assume a level backfill with no surcharge. Our design values will need to be revised for sloping backfill or other dead or live loads that are placed within a horizontal distance behind the walls that is equal to the height of the walls. Our design values also assume that the walls are drained so that water cannot accumulate behind the walls.

Resistance to lateral earth pressures will be provided by passive resistance against the wall footings and by sliding resistance along the bottoms of the wall footings. In areas where footings are embedded in the bedrock, we recommend assuming a passive pressure equal to 5 tsf. In areas where the edges of the footings are in contact with soil, we recommend assuming a passive pressure equal to 350 pcf. We recommend a sliding coefficient of 0.7 for footings bearing on bedrock and 0.45 for footings bearing on alluvial sands. These values are un-factored.

D.7. Exterior Slabs

Though not necessarily designed to accommodate dead and live load surcharges or vehicles, exterior slabs can be subjected to both. Settlement of exterior slabs on poorly compacted foundation backfill, utility backfill and other compressible naturally deposited soils or fills can also contribute to unfavorable surface drainage conditions and frost-related damage (see below) to the slabs and adjacent structures, including buildings and pavements. Subgrades supporting exterior slabs should therefore be prepared in accordance with the excavation, backfilling and compaction recommendations provided below in Section D.2. Additional commentary on the risks associated with frost, and recommendations for helping mitigate those risks, is provided in Section D.10 below.

D.8. Pavements

D.8.a. Pavement Subgrade Preparation

We recommend stripping all existing pavements and surface compacting the exposed subgrades with a large vibratory sheepsfoot compactor prior to placement of the base section. If soils containing organics (as seen in the upper 2 feet of Boring ST-5) or debris are encountered at pavement subgrade elevations, additional excavation and replacement may be required.

On-site soils free of organic soil and debris can be considered for placement up to design subgrade elevations in pavement areas. In order to maintain a relatively consistent subgrade R-value across the site, imported fill placed below pavement subgrades should consist of sand having less than 20 percent of the particles by weight passing a #200 sieve.

We recommend compacting excavation backfill (including utility backfill) and additional required fill placed within 3 feet of pavement subgrade elevations to at least 100 percent of their maximum standard Proctor dry densities (ASTM D 698). Backfill and fill placed more than 3 feet below pavement subgrade elevations should be compacted to at least 95 percent. Backfill and fill should be compacted at moisture contents within 3 percent of their optimum moisture contents.

D.8.b. Subgrade Proofroll

Prior to placing aggregate base material, we recommend proofrolling pavement subgrades to determine if the subgrade materials are loose, soft or weak, and in need of further stabilization, compaction or subexcavation and recompaction or replacement. A second proofroll should be performed after the aggregate base material is in place, and prior to placing bituminous or concrete pavement.

D.8.c. Design Sections

Laboratory tests to determine an R-value for pavement design were not included in the scope of this project. Based on our experience with similar projects in the area, however, it is our opinion that an R-value of 30 can be assumed for design purposes.

Based upon the aforementioned traffic loads and an R-value of 30, we recommend pavement section that includes 4 inches of bituminous pavement (a 2-inch surface course over a 2-inch base course) over 6 inches of aggregate base material.

Where concrete pavements will be used, we recommend that at least 4 inches of aggregate base be placed over the subgrade to provide more uniform support for the concrete, and to provide a more stable working platform for construction. We recommend a minimum 6-inch thick concrete slab, based on a modulus of subgrade reaction (k) of 200 pci.

The above pavement designs are based upon a 20-year performance life for bituminous and a 35-year performance life for concrete. This is the amount of time before major reconstruction is anticipated. This performance life assumes maintenance, such as seal coating and crack sealing, is routinely performed. The actual pavement life will vary depending on variations in weather, traffic conditions and maintenance.

D.8.d. Materials and Compaction

We recommend specifying crushed aggregate base meeting the requirements of Minnesota Department of Transportation (MnDOT) Specification 3138 for Class 5. We recommend that the bituminous wear and base courses meet the requirements of Specifications 2360, Type SP. We recommend the aggregate gradations for the asphalt mixes meet Gradation B for the base course and Gradation B or A for the surface course. Gradation A contains a smaller aggregate size than Gradation B and will provide a surface with less visible aggregate which is desirable for some owners. We recommend the Performance Graded Asphalt cement be a PG 58-28. (If additional resistance to rutting, scuffing and dimpling is desired, we recommend utilizing a PG 64-28. If additional resistance to cold weather cracking is desirable, we recommend utilizing a PG 58-34.)

We recommend that the aggregate base be compacted to a minimum of 100 percent of its maximum standard Proctor dry density. We recommend that the bituminous pavement be compacted to at least 92 percent of the maximum theoretical Rice density.

We recommend specifying concrete for pavements that has a minimum 28-day compressive strength of 4,000 psi, and a modulus of rupture (M_r) of at least 600 psi. We also recommend Type I cement meeting the requirements of ASTM C 150. We recommend specifying 5 to 7 percent entrained air for exposed concrete to provide resistance to freeze-thaw deterioration. We also recommend using a water/cement ratio of 0.45 or less for concrete exposed to deicers.

D.8.e. Subgrade Drainage

We recommend installing perforated drainpipes throughout pavement areas at low points and about catch basins. The drainpipes should be placed in small trenches extended at least 8 inches below the granular subbase layer, or below the aggregate base material where no subbase is present.

D.9. Utilities

D.9.a. Subgrade Stabilization

The alluvial sands and bedrock appear suitable for support of utilities. The bottoms of excavations for utilities to be installed in existing fill should be evaluated for stability by a geotechnical engineer prior to placement of bedding materials. If the exposed soils are found to be unstable or unsuitable for proper placement of bedding materials, additional excavation and replacement with stabilizing aggregate may be required.

Excavations for utilities installed in the bedrock should be adequately oversized to allow for proper pipe bedding.

D.9.b. Selection, Placement and Compaction of Backfill

We recommend selecting, placing and compacting utility backfill in accordance with the recommendations provided above in Section D.2.

D.9.c. Dewatering

The contractor should be prepared to remove perched groundwater and surface water runoff from the utility excavations. In addition, if utilities are installed below an elevation of 987 feet, the contractor should be prepared to mitigate seepage during Zumbro River flood events.

D.9.d. Corrosion Potential

The on-site clayey sands are considered moderately corrosive. If utility trenches are backfilled with these materials, we recommend providing corrosion protection for ductile iron pipe. If utilities are bedded and backfilled with sands or gravels, corrosion protection will not be required. We recommend concrete utilities contain Type II cement.

D.10. Frost Protection

D.10.a. General

Some of the exterior slabs and pavements may be underlain with lean clays, clayey sands, and/or silty sands which are considered to be moderately to highly frost susceptible. Soils of these types can retain moisture and heave upon freezing. In general, this characteristic is not an issue unless these soils become saturated due to surface runoff or infiltration or are excessively wet in-situ. Once frozen, unfavorable amounts of general and isolated heaving of the soils and the surface structures supported on them could develop. This type of heaving could impact design drainage patterns and the performance of exterior slabs and pavements, as well as any isolated exterior footings and piers. To address most of the heave related issues, we recommend that general site grades and grades for exterior surface features be set to direct surface drainage away from buildings and away from walkways to limit the potential for saturation of the subgrade and any subsequent heaving. General grades should also have enough “slope” to tolerate potential larger areas of heave which may not fully settle when thawed.

It should be noted that general runoff and infiltration from precipitation are not the only sources of water that can saturate subgrade soils and contribute to frost heave. Roof drainage and the irrigation of landscaped areas in close proximity to exterior slabs, pavements, and isolated footings and piers contribute as well.

D.10.b. Exterior Slabs and Pavements

Even small amounts of frost-related differential movement at walkway joints or cracks can create tripping hazards. Several subgrade improvement options can be explored to address this condition. The most conservative and potentially most costly subgrade improvement option to help limit the potential for heaving, but not eliminate it, would be to remove any frost-susceptible soils present below the exterior slabs’ “footprint” down to the bottom-of-footing grades or to a maximum depth of 5 feet below subgrade elevations, whichever is less. We recommend the resulting excavation then be refilled with sand or sandy gravel having less than 50 percent of the particles by weight passing the #40 sieve and less than 5 percent of the particles by weight passing a #200 sieve. The bottom of the excavation should be sloped toward one or more collection points so that any water entering the backfill can be collected and removed. A series of perforated drainpipes will need to be installed to collect and dispose of the infiltrating water and/or groundwater that could accumulate within the backfill. The piping should be connected to a storm sewer or a sump to remove any accumulated water, or "day lighted" if grades permit. If the water is not removed, it is our opinion this option will not be effective in controlling heave.

Another subgrade improvement option would be to build in a transition zone between those soils considered to be frost-susceptible and those that are not to somewhat control where any differential movement may occur. Such transitions could exist between exterior slabs and pavements, between entry way slabs and sidewalks, and along the sidewalks themselves. For this option, the frost-susceptible soils in critical areas would be removed to a depth of at least 5 feet below grade as discussed above. The excavation below the footprint of the sidewalks or other slabs would then be sloped upward at a gradient no steeper than 3:1 (horizontal:vertical) toward the less critical areas. Provisions for draining the backfill in this case, too, would be required. If accumulating water is not removed, it is our opinion this option will also be ineffective in controlling heave.

Regardless of what is done to the walkway or pavement area subgrade, it will be critical the end-user develop a detailed maintenance program to seal and/or fill any cracks and joints that may develop during the useful life of the various surface features. Concrete will experience episodes of normal thermo-expansion and thermo-contraction during its useful life. During this time, cracks may develop and joints may open up, which will expose the subgrade and allow any water flowing overland to enter the subgrade and either saturate the subgrade soils or to become perched atop it. This occurrence increases the potential for heave due to freezing conditions in the general vicinity of the crack or joint. This type of heave has the potential to become excessive if not addressed as part of a maintenance program. Special attention should be paid to areas where dissimilar materials abut one another, where construction joints occur and where shrinkage cracks develop.

The on-going performance of pavements is impacted by conditions under which the pavement is asked to perform. These conditions include the environmental conditions, the actual use conditions and the level of ongoing maintenance performed. With regard to bituminous pavements in particular, because of normal thermo expansion and contraction, it is not unusual to have cracking develop within the first few years of placement and for the cracking to continue throughout the life of the pavement. A regular maintenance plan should be developed for filling cracks in bituminous pavements to lessen the potential impacts for cold weather distress due to frost heave or warm weather distress due to wetting and softening of the subgrade. It is also not unusual for bituminous pavements to require a seal coat within the first 5 to 10 years to increase the long-term performance.

D.10.c. Isolated Footing and Piers

Soils classifying as "silt" (USCS symbols ML or MH), "clay" (CL or CH), or as being "silty" or "clayey" (including but not limited to SP-SM, SC-SM, SM or SC), have the potential for adhering to poured concrete or masonry block features built through the normal frost zone. In freezing conditions, this soil adhesion could result in the concrete or masonry construction being lifted out of the ground. This lifting action is also known as heave due to adfreezing. The potential for experiencing the impacts of adfreezing increases with poor surface drainage in the area of below grade elements, in areas of poorly compacted clayey or silty soils and in areas of saturated soils. To limit the impacts of adfreeze, we recommend placing a low friction separation barrier, such as high density insulation board, between the backfill and the element. Extending isolated piers deeper into the frost-free zone, enlarging the bottom of the piers and then providing tension reinforcement can also be considered. Recommendations for specific foundation conditions can be provided as needed.

D.11. Construction Quality Control

D.11.a. Excavation Observations

We recommend having a geotechnical engineer observe all excavations related to subgrade preparation, spread footings, pavements, and grade-supported slabs. The purpose of the observations is to evaluate the competence of the geologic materials exposed in the excavations, and the adequacy of required excavation oversizing.

D.11.b. Materials Testing

We recommend density tests be taken in excavation backfill and additional required fill placed below spread footings, slab-on-grade construction, beside below-grade walls, and below exterior slabs and pavements.

We also recommend slump, air content and strength tests of Portland cement concrete.

D.11.c. Pavement Subgrade Proofroll

We recommend that proofrolling of the pavement subgrades be observed by a geotechnical engineer to determine if the results of the procedure meet project specifications, or delineate the extent of additional pavement subgrade preparation work.

D.11.d.Cold Weather Precautions

If site grading and construction is anticipated during cold weather, all snow and ice should be removed from cut and fill areas prior to additional grading. No fill should be placed on frozen subgrades. No frozen soils should be used as fill.

Concrete delivered to the site should meet the temperature requirements of ASTM C 94. Concrete should not be placed on frozen subgrades. Concrete should be protected from freezing until the necessary strength is attained. Frost should not be permitted to penetrate below footings.

E. Procedures

E.1. Penetration Test Borings

The penetration test borings were drilled with an ATV-mounted core and auger drill equipped with hollow-stem auger. The borings were performed in accordance with ASTM D 1586. Penetration test samples were taken at 2 1/2- or 5-foot intervals. Actual sample intervals and corresponding depths are shown on the boring logs.

Penetration test boreholes that met the Minnesota Department of Health (MDH) Environmental Borehole criteria were sealed with an MDH-approved grout.

E.2. Rock Cores

Rock cores were taken with an NQ-3 core barrel. The bit and casing were first lowered to the bottom of the previously advanced borehole. The core barrel was then lowered into the casing with a wire line, and locked into place. The bit and barrel were advanced by rotating the assembly while applying pressure. Bentonite drilling mud was used to cool the bit and wash cuttings to the surface. Bit pressure, rate of advance, fluid pressure and fluid return were noted as coring progressed. Intervals in which a rapid rate of advance, or a sudden loss of fluid pressure or return suggested voids were present, were noted, as were intervals where a loss of bit pressure, an increase in fluid pressure and a loss of fluid return indicated plugging of the bit by shale.

After each core run was completed, the core barrel was unlocked from the bit and brought to the surface. The split inner tube was then extruded from the barrel and opened to reveal the core sample.

After field classification and logging, the core was packed into a wood storage box, arranged into 5-foot long sections.

E.3. Material Classification and Testing

E.3.a. Visual and Manual Classification

The geologic materials encountered were visually and manually classified in accordance with ASTM Standard Practice D 2488. A chart explaining the classification system is attached. Samples were placed in jars or bags and returned to our facility for review and storage.

E.3.b. Organic Vapor Screening

Material samples retrieved during drilling were screened for the presence of organic vapors with a photoionization detector (PID) using both: (1) direct readings from each sample, and (2) the headspace method of analysis recommended in "Soil Sample Collection and Analysis Procedures," Minnesota Pollution Control Agency (MPCA) Petroleum Remediation Guidance Document 4-04 (September 2008). The PID was equipped with a 10.6 eV lamp and calibrated to an isobutylene standard prior to the start of field work.

E.4. Groundwater Measurements

The drillers checked for groundwater as the penetration test borings were advanced, and again after auger withdrawal. The boreholes were then backfilled or allowed to remain open for an extended period of observation as noted on the boring logs.

F. Qualifications

F.1. Variations in Subsurface Conditions

F.1.a. Material Strata

Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth, and therefore strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions, and can be expected to vary in depth, elevation and thickness away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed, or construction commences. If any such variations are revealed, our recommendations should be re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

F.1.b. Groundwater Levels

Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

F.2. Continuity of Professional Responsibility

F.2.a. Plan Review

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

F.2.b. Construction Observations and Testing

It is recommended that we be retained to perform observations and tests during construction. This will allow correlation of the subsurface conditions encountered during construction with those encountered by the borings, and provide continuity of professional responsibility.

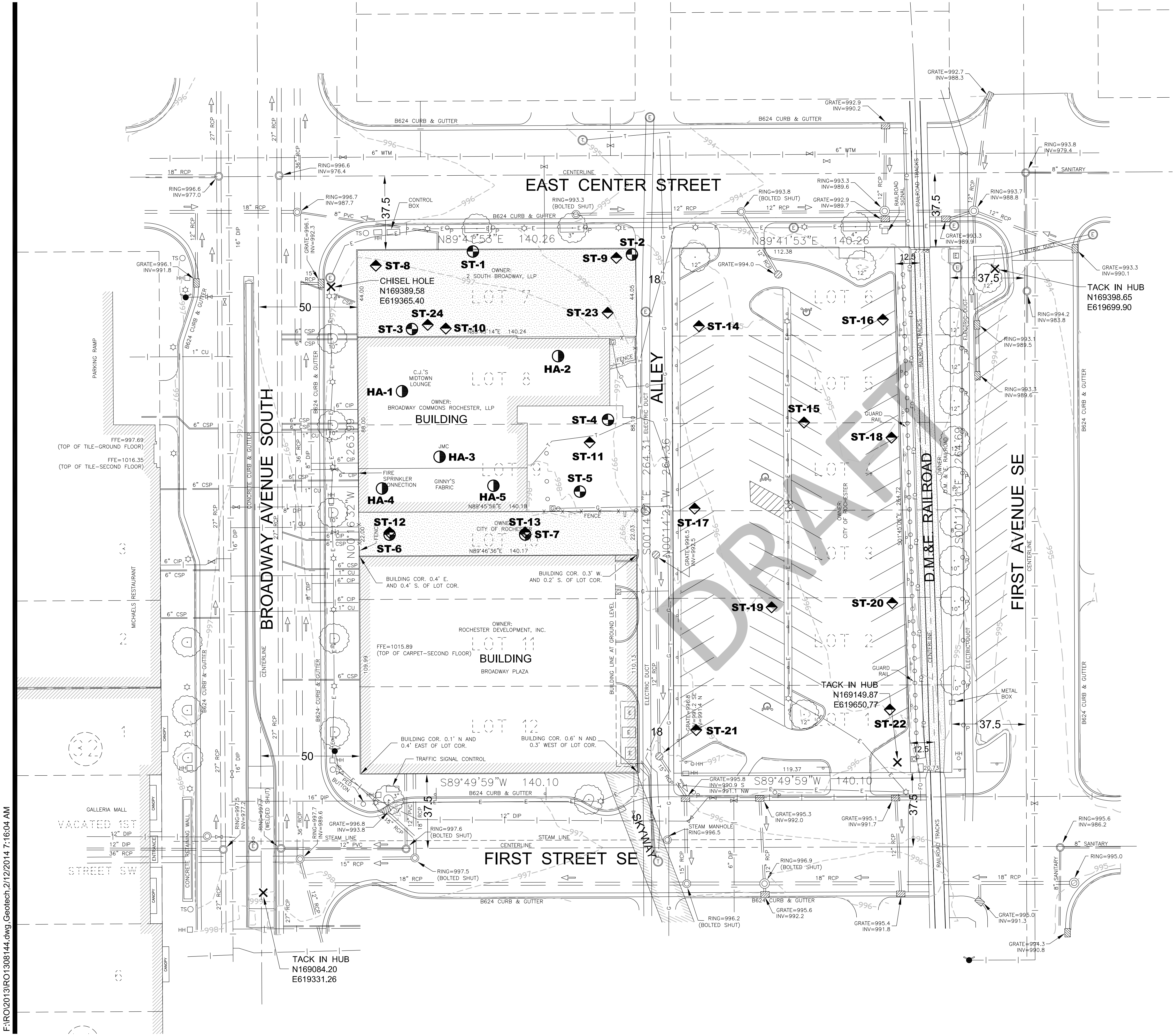
F.3. Use of Report

This report is for the exclusive use of Titan Development and Investments. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

F.4. Standard of Care

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Appendix



DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING

DENOTES APPROXIMATE LOCATION OF PREVIOUS SOIL BORING

DENOTES APPROXIMATE LOCATION OF HAND AUGER BORING

25' 0 50'

SCALE: 1"= 50'

BRAUN INTERTEC

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Minneapolis, MN 55438
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Base Dwg Provided By:

SOIL BORING LOCATION SKETCH
GEOTECHNICAL EVALUATION
BROADWAY AT CENTER
BROADWAY AVENUE AND CENTER STREET
ROCHESTER, MINNESOTA

Project No:	RO1308144A
Drawing No:	RO1308144
Scale:	1"= 50'
Drawn By:	JAG
Date Drawn:	1/2/14
Checked By:	CNE
Last Modified:	2/12/14
Sheet: of	Fig:

BRAUN INTERTEC

LOG OF BORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

BORING: **ST-14**

LOCATION: See attached sketch.

DRILLER: R. Hansen | METHOD: 3 1/4" HSA, Autohammer | DATE: **1/29/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 995.4	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
995.1	0.3	PAV	3 inches of Bituminous Pavement.				
993.4	2.0	FILL	FILL: Clayey Sand, dark brown, frozen.				
992.4	3.0	FILL	FILL: Poorly Graded Sand with Silt, fine- to coarse-grained, trace of Gravel, brown, frozen.			0.8	
991.4	4.0	SP	POORLY GRADED SAND, fine- to medium-grained, light brown, frozen. (Alluvium)	58*		0.3	* High blow counts likely due to frost.
989.4	6.0	SP-SM	POORLY GRADED SAND with SILT, fine- to medium-grained, light brown, moist, medium dense. (Alluvium)	23		0.5	
986.4	9.0	SP-SM	POORLY GRADED SAND with SILT, fine- to coarse-grained, with GRAVEL, brown, moist, loose. (Alluvium)	8		0.1	
985.4	10.0	SP-SM	POORLY GRADED SAND with SILT, fine- to medium-grained, brown, moist, loose. (Alluvium)	6		0.1	
981.4	14.0	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, brown, moist, decomposed, very fine- to fine-grained. Retrieved as "Silty Sand (SM)" with Gravel-sized pieces of Sandy Dolstone in split-spoon sampler.	14		0.1	* No sample recovery.
978.9	16.5	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown, dry, highly weathered, very fine- to fine-grained. Retrieved as "Silty Gravel with Sand (GM)" in split-spoon sampler.			0.1	
			END OF BORING - REFUSAL TO AUGER AT 16.5 FEET. Water not observed while drilling. Boring then grouted.	*		0.1	* 20/6" (set), then 50/4"

DRAFT

LOG OF BORING N:\GINT\PROJECTS\ROCHESTER\2013\08144B.GPJ BRAUN_V8_CURRENT.GDT 3/14/14 09:05

BRAUN INTERTEC

LOG OF BORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

BORING: **ST-15**

LOCATION: See attached sketch.

DRILLER: R. Hansen | METHOD: 3 1/4" HSA, Autohammer | DATE: **1/30/14** | SCALE: **1" = 4'**

Elev. feet 995.4	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
995.1	0.3	PAV	3 inches of Bituminous Pavement.				
993.4	2.0	FILL	FILL: Silty Sand, fine- to medium-grained, with Gravel, brown, frozen.				
992.4	3.0	FILL	FILL: Clayey Sand, with Gravel, black, frozen.			0.1	
991.4	4.0	FILL	FILL: Poorly Graded Sand with Silt, fine- to coarse-grained, with Gravel, light brown, moist.	89*			* High blow counts likely due to frost.
990.4	5.0	FILL	FILL: Clayey Sand, with Gravel, dark brown, moist.			0.2	
987.4	8.0	SP-SM	POORLY GRADED SAND with SILT, fine- to coarse-grained, with GRAVEL, brown, moist, medium dense. (Alluvium)	21		0.1	
983.4	12.0	SP	POORLY GRADED SAND, fine- to medium-grained, brown, moist, medium dense. (Alluvium) - Trace of Gravel at 10 feet.	12 18		0.2 0.2	
978.4	17.0	SP	POORLY GRADED SAND, fine-grained, light brown, moist, medium dense. (Alluvium)	18 17		0.1 0.1 0.2	An open triangle in the water level (WL) column indicates the depth at which groundwater was first observed while drilling. Groundwater levels fluctuate.
976.4	19.0	SP	POORLY GRADED SAND, fine- to coarse-grained, with GRAVEL, light brown, moist, medium dense. (Alluvium)	22		0.1	
971.4	24.0	SP	POORLY GRADED SAND, fine- to medium-grained, brown, wet to waterbearing, medium dense. (Alluvium)	27	▽	0.1 0.1	

END OF BORING - REFUSAL TO AUGER AT 24 FEET.

Trace of water observed while drilling.

Water observed at 22 feet with 24 feet of hollow-stem auger in the ground.

Boring then grouted.

(See Descriptive Terminology sheet for explanation of abbreviations)

BRAUN INTERTEC

LOG OF BORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

BORING: **ST-16**

LOCATION: See attached sketch.

DRILLER: R. Hansen | METHOD: 3 1/4" HSA, Autohammer | DATE: **1/29/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 994.8	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
994.5	0.3	BIT	3 inches of Bituminous Pavement.				
991.8	3.0	FILL	FILL: Silty Sand, fine-grained, black, frozen. - Debris and coal slag observed.			2.1	
986.8	8.0	SP	POORLY GRADED SAND, fine- to coarse-grained, with gravel, light brown, moist. (Alluvium)	26 25 25		0.2 0.3	
980.8	14.0	SP	POORLY GRADED SAND, fine- to medium-grained, light brown, moist. (Alluvium)	19 20		0.7 0.4 0.5	
977.8	17.0	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, brown, moist, decomposed, very fine- to fine-grained. Retrieved as "Lean Clay with Sand (CL)" with Gravel-sized pieces of Sandy Dolostone in split-spoon sampler.	10		0.9 0.3	
971.8	23.0	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown, moist, decomposed to highly weathered, very fine- to fine-graied. Retrieved as "Clayey Sand (SC)" with Gravel-sized pieces of Sandy Dolostone in split-spoon sampler.	41 26	▽	0.3	
970.3	24.5	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, brown, wet, highly weathered, very fine-grained. Retrieved as "Silty Gravel (GM)" with split spoon sampler.	*			*50/4 (set)

END OF BORING - REFUSAL TO AUGER AT 24.5 FEET.

Water observed at a depth of 24 1/2 feet while drilling.

Water observed at a depth of 21 feet with 24 1/2 feet of hollow-stem auger in the ground.

Boring then grouted.

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LOG OF BORING

BRAUN INTERTEC

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

BORING: **ST-17**

LOCATION: See attached sketch.

DRILLER: R. Hansen | METHOD: 3 1/4" HSA, Autohammer | DATE: **1/29/14** | SCALE: **1" = 4'**

Elev. feet 996.2	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
995.9	0.3	PAV	3 inches of Bituminous Pavement.				
994.2	2.0	FILL	FILL: Clayey Gravel, with Sand, brown, frozen.				
993.2	3.0	FILL	FILL: Poorly Graded Sand with Silt, fine- to medium-grained, with Gravel, brown, frozen.			0.7	
991.2	5.0	SP-SM	POORLY GRADED SAND with SILT, fine- to coarse-grained, trace of Gravel, brown, frozen. (Alluvium)	70*		0.5	* High blow counts likely due to frost.
990.2	6.0	SP-SM	POORLY GRADED SAND with SILT, fine- to medium-grained, brown, frozen. (Alluvium)	21		0.8	
989.2	7.0	SM	SILTY SAND, fine- to medium-grained, brown, moist, medium dense. (Alluvium)				
988.2	8.0	SP	POORLY GRADED SAND, fine- to coarse-grained, trace of Gravel, brown, moist, medium dense. (Alluvium)	14		0.4	
982.2	14.0	SP	POORLY GRADED SAND, fine- to medium-grained, brown, moist, medium dense. (Alluvium)	18 14		0.2 0.2	
977.2	19.0	SP	POORLY GRADED SAND, fine- to medium-grained, trace of Gravel, brown, moist, medium dense. (Alluvium)	12 19		0.1 0.1 0.1	
976.7	19.5	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown, dry, decomposed to highly weathered, very fine- to fine-grained. Retrieved as "Silty Gravel with Sand (GM)" in split-spoon sampler.				* Poor sample recovery.

END OF BORING - REFUSAL TO AUGER AT 19.5 FEET.

Water not observed while drillling.

Boring then grouted.

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(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\ROCHESTER\2013\08144B.GPJ BRAUN_V8_CURRENT.GDT 3/14/14 09:06

LOG OF BORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

BORING: **ST-18**
LOCATION: See attached sketch.

DRILLER: R. Hansen	METHOD: 3 1/4" HSA, Autohammer	DATE: **1/29/14**	SCALE: **1" = 4'**

Elev. feet 995.2	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
994.9	0.3	BIT	3 inches of Bituminous Pavement.				
993.2	2.0	FILL	FILL: Clayey Sand with Gravel, brown, frozen.				
992.2	3.0	FILL	FILL: Clayey Sand with Gravel, black, frozen.			0.2	
990.2	5.0	SP	POORLY GRADED SAND, fine- to coarse-grained, with Gravel, brown, moist. (Alluvium)	52*		0.4	* High blow counts likely due to frost.
983.2	12.0	SP	POORLY GRADED SAND, fine- to coarse-grained, trace of Gravel at 6 feet, light brown, moist, dense to medium dense. (Alluvium)	36 19 24		1.2 0.5 0.4	
981.2	14.0	SP	POORLY GRADED SAND, fine- to medium-grained, light brown, moist, medium dense. (Alluvium)	27		0.1	
976.2	19.0	SP	POORLY GRADED SAND, fine-grained, light brown, moist, medium dense. (Alluvium)	30 19		0.1 0.3 0.4	
972.2	23.0	SP	POORLY GRADED SAND, fine- to medium-grained, light brown, wet to waterbearing, medium dense. (Alluvium)	15	▽	0.1	
968.9	26.3	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, brown, waterbearing, highly weathered, very fine-grained. Retrieved as "Poorly Graded Gravel (GP)" with split spoon sampler.	*			*50/7" (set).
			Boring continued as cored borehole				

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\ROCHESTER\2013\08144B.GPJ BRAUN_V8_CURRENT.GDT 3/14/14 09:06

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LOG OF CORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

CORING: **ST-18 (cont.)**

LOCATION: See attached sketch.

DATE: **1/29/14** SCALE: **1" = 1'**

Elev. feet 968.9	Depth feet 26.3	Description of Core	Bit Pressure (psi)	Rate of Advance (min/ft)	Water Press (psi)	Water Return (%)	Rec. %	RQD %	Remarks
968.9	26.3	SHAKOPEE FORMATION, SANDSTONE, light brown and brown, moist, highly weathered, moderately hard to hard, very fine- to fine-grained, thin-bedded, intensely fractured with vugs throughout.	4650	1.3	15-20	75	68	9	
967.9	27.3	SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown and light gray, moist, highly to moderately weathered, hard, very fine to fine-grained, thin-bedded, intensely to highly fractured, with Calcite healed fractures throughout.		2.1					
				1.5					
966.4	28.8	SHAKOPEE FORMATION, SANDSTONE, light brown, moist, highly weathered, moderately hard to hard, very fine- to fine-grained, thin-bedded, intensely to highly fractured, with vugs.		1.3					
				1.6					
964.4	30.8	SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown and light gray, moist, highly to moderately weathered, hard, very fine- to fine-grained, vuggy, thin-bedded, intensely							
963.9	31.3								

Continued Next Page

NOTES:

BRAUN INTERTEC

LOG OF CORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

CORING: **ST-18 (cont.)**

LOCATION: See attached sketch.

DATE: **1/29/14** SCALE: **1" = 1'**

Elev. feet 963.9	Depth feet 31.3	Description of Core	Bit Pressure (psi)	Rate of Advance (min/ft)	Water Press (psi)	Water Return (%)	Rec. %	RQD %	Remarks
		fractured.	4650	2.1	15-20	75	100	87	
		SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown and light gray, moist, highly to moderately weathered, hard, very fine- to fine-grained, intensely to moderately fractured, vuggy, with Calcite healed fractured throughout.							
				2.8					* Sand locked inner barrel.
				1.3					
961.3	33.9	END OF COREHOLE.							
		Water observed at 20.6 feet while drilling.							
		Boring and corehole then grouted.							

NOTES:

BRAUN INTERTEC

BRAUN INTERTEC

LOG OF BORING

Braun Project RO-13-08144B Geotechnical Evaluation Broadway at Center Parking Ramp Broadway Avenue and Center Street Rochester, Minnesota	BORING: ST-19 LOCATION: See attached sketch.

DRILLER: R. Hansen	METHOD: 3 1/4" HSA, Autohammer	DATE: 1/30/14	SCALE: 1" = 4'

Elev. feet 996.1	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
995.8	0.3	PAV	3 inches of Bituminous Pavement.				
994.1	2.0	FILL	FILL: Silty Sand, with Gravel, brown, frozen.				
993.1	3.0	FILL	FILL: Clayey Sand, with Gravel, black, frozen.			0.3	
991.1	5.0	FILL	FILL: Poorly Graded Sand with Silt, fine- to coarse-grained, trace of Gravel at 4 feet, brown, frozen.	123*		0.2	* High blow counts likely due to frost.
989.1	7.0	SM	SILTY SAND, trace of Gravel, brown, moist, medium dense. (Alluvium)	21		0.1	
988.1	8.0	SP-SM	POORLY GRADED SAND with SILT, trace of Gravel, brown, moist, loose. (Alluvium)	6		0.1	
987.1	9.0	SC	CLAYEY SAND, trace of Gravel, brown, moist, medium. (Alluvium)	29		0.1	
985.1	11.0	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, brown, moist, decomposed, very fine- to fine-grained. Retrieved as "Clayey Sand (SC)" with Gravel-sized pieces of Sandy Dolostone in split-spoon sampler.				
			END OF BORING - REFUSAL TO AUGER AT 11 FEET. Water not observed while drilling. Boring then backfilled.				

BRAUN INTERTEC

LOG OF BORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

BORING: **ST-20**

LOCATION: See attached sketch.

DRILLER: R. Hansen | METHOD: 3 1/4" HSA, Autohammer | DATE: **1/29/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 995.6	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
995.3	0.3	PAV	3 inches of Bituminous Pavement.				
993.6	2.0	FILL	FILL: Clayey Gravel, with Sand, brown, frozen.				
992.6	3.0	FILL	FILL: Clayey Sand, with Gravel, black, frozen.			0.7	
991.6	4.0	FILL	FILL: Poorly Graded Sand, fine- to medium-grained, brown, moist.	25			
988.6	7.0	FILL	FILL: Poorly Graded Sand with Silt, fine- to coarse-grained, with Gravel, brown, moist.	20		0.4 0.1	
987.6	8.0	SM	SILTY SAND, fine- to medium-grained, brown to dark brown, moist, medium dense. (Alluvium)	15		0.2	
985.6	10.0	SP	POORLY GRADED SAND, fine- to medium-grained, brown, moist, medium dense. (Alluvium) - Trace of Gravel at 9 feet.	34		0.3	
976.6	19.0	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown, brown and light gray, moist, decomposed to highly weathered, very fine- to fine-grained. Retrieved as mixture of "Poorly Graded Sand with Silt (SP-SM), Poorly Graded Gravel with Silt (GP), Silty Sand (SM), and Silty Gravel with Sand (GM)" with Gravel-sized pieces of Sandy Dolostone in split-spoon sampler.	* 19 *		0.1 0.1 0.2	* 11/6" (set), then 50/11" * 50/5" (set)
975.3	20.3	SS	SHAKOPEE FORMATION, SANDSTONE, light brown to white, moist, decomposed to highly weathered, very fine- to fine-grained. Retrieved as "Poorly Graded Sand with Silt (SP-SM)" with Gravel-sized pieces of Sandy Dolostone in split-spoon sampler.	*			* 50/6" (set), then 50/3"

END OF BORING - REFUSAL TO AUGER AT 20.3 FEET.

Water not observed while drilling.

Boring then grouted.

BRAUN INTERTEC

LOG OF BORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

BORING: **ST-21**

LOCATION: See attached sketch.

DRILLER: R. Hansen | METHOD: 3 1/4" HSA, Autohammer | DATE: **1/29/14** | SCALE: **1" = 4'**

Elev. feet 997.0	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
996.7	0.3	BIT	3 inches of Bituminous Pavement.				
995.0	2.0	FILL	FILL: Silty Sand, fine- to medium-grained, brown, frozen.				
993.0	4.0	FILL	FILL: Clayey Sand, brown, frozen.	58*		6.0	* High blow counts likely due to frost.
991.0	6.0	FILL	FILL: Clayey Sand with Gravel, brown, moist.	12		0.5	
989.0	8.0	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, brown, dry to moist, highly weathered, fine- to very fine-grained. Retrieved as "Silty Gravel with Sand (GM)" in split spoon sampler.	*		0.6 0.3	* 9/6" (set), then 50/6"
			END OF BORING - REFUSAL TO AUGER AT 8 FEET. Water not observed while drilling. Boring then backfilled.				

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\ROCHESTER\2013\08144B.GPJ BRAUN_V8_CURRENT.GDT 3/14/14 09:06

BRAUN INTERTEC

LOG OF BORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

BORING: **ST-22**

LOCATION: See attached sketch.

DRILLER: R. Hansen | METHOD: 3 1/4" HSA, Autohammer | DATE: **1/31/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 996.1	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	PID (ppm)	Tests or Notes
995.8	0.3	BIT	3 inches of Bituminous Pavement.				
993.1	3.0	FILL	FILL: Silty Gravel, with Sand, dark brown, frozen.			1.4	
991.1	5.0	FILL	FILL: Poorly Graded Sand with Silt, fine- to coarse-grained, with Gravel, brown, frozen.	50*		1.2	* High blow counts likely due to frost.
987.1	9.0	FILL	FILL: Clayey Gravel, with Gravel, brown, moist.	20 18		0.8 1.0	
985.1	11.0	FILL	FILL: Clayey Sand, with Gravel, brown, light brown, and black, moist.	*		0.9	* 50/5" (set)
982.3	13.8	DOL	SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown and light gray, dry to moist, decomposed to highly weathered, very fine- to fine-grained. Retrieved as "Silty Gravel with Sand (GM)" in split-spoon sampler.	* *		0.9	* 50/6" (set) * 50/3" (set)
			Boring continued as cored borehole				

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LOG OF BORING N:\GINT\PROJECTS\ROCHESTER\2013\08144B.GPJ BRAUN_V8_CURRENT.GDT 3/14/14 09:06

LOG OF CORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

CORING: **ST-22 (cont.)**

LOCATION: See attached sketch.

DATE: **1/31/14** SCALE: **1" = 1'**

Elev. feet 982.3	Depth feet 13.8	Description of Core	Bit Pressure (psi)	Rate of Advance (min/ft)	Water Press (psi)	Water Return (%)	Rec. %	RQD %	Remarks
982.3	13.8	SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown and light gray, moist, highly weathered, moderately hard, very fine- to fine-grained, thin-bedded, intensely to highly fractured, thin Sandstone seams between 14 and 15 feet, large Chert nodule around 18 feet.	4650	2.7	15-20	70	37	0	
				3.0		60			* Inner core barrel pulled at 15 feet due to core barrel blockage.
				3.5					
				2.4		50			
				6.4					
977.3	18.8								

Continued Next Page

NOTES:

BRAUN℠ INTERTEC

LOG OF CORING

Braun Project RO-13-08144B
Geotechnical Evaluation
Broadway at Center Parking Ramp
Broadway Avenue and Center Street
Rochester, Minnesota

CORING: **ST-22 (cont.)**

LOCATION: See attached sketch.

DATE: **1/31/14** SCALE: **1" = 1'**

Elev. feet 977.3	Depth feet 18.8	Description of Core	Bit Pressure (psi)	Rate of Advance (min/ft)	Water Press (psi)	Water Return (%)	Rec. %	RQD %	Remarks
976.3	19.8	SHAKOPEE FORMATION, DOLOSTONE, light gray, moist, highly weathered, moderately hard, very fine- to fine-grained, thin-bedded, highly fractured.	4650	4.3	15-20	4	85	45	
		SHAKOPEE FORMATION, SANDY DOLOSTONE, light brown and light gray, decomposed to highly weathered, soft to moderately hard, very fine- to fine-grained, thin-bedded, intensely to highly fractured, with Shale seams and Chert nodules. Thin Sandstone seam around 20 feet.		1.7					
974.3	21.8			1.9					
		SHAKOPEE FORMATION, DOLOSTONE, light gray and reddish brown, moist, highly weathered, moderately hard, very fine- to fine-grained, thin-bedded, intensely to highly fractured, thin Shale seams throughout, prevelant iron staining.		2.6					Temporary monitoring well installed at 23.8 feet. Groundwater level observed at 20.9 feet after 3 days.
972.3	23.8	*		2.7					* END OF COREHOLE. Boring and corehole then grouted.

NOTES:

BRAUN INTERTEC

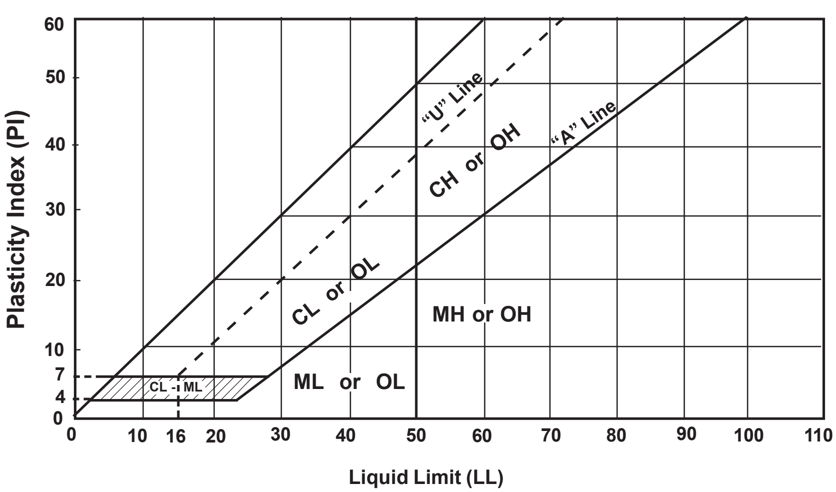
Descriptive Terminology of Soil

BRAUN INTERTEC

Standard D 2487 - 00
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels 5% or less fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands 5% or less fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line [j]	CL	Lean clay [k l m]
			PI < 4 or plots below "A" line [j]	ML	Silt [k l m]
		Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay [k l m n]
				OL	Organic silt [k l m o]
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [k l m]
			PI plots below "A" line	MH	Elastic silt [k l m]
		Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay [k l m p]
				OH	Organic silt [k l m q]
Highly Organic Soils		Primarily organic matter, dark in color and organic odor		PT	Peat

a. Based on the material passing the 3-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. Gravels with 5 to 12% fines require dual symbols:
   GW-GM well-graded gravel with silt
   GW-GC well-graded gravel with clay
   GP-GM poorly graded gravel with silt
   GP-GC poorly graded gravel with clay
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines" to group name.
h. If soil contains ≥15% gravel, add "with gravel" to group name.
i. Sands with 5 to 12% fines require dual symbols:
   SW-SM well-graded sand with silt
   SW-SC well-graded sand with clay
   SP-SM poorly graded sand with silt
   SP-SC poorly graded sand with clay
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 to 29% plus No. 200, add "with sand" or "with gravel" whichever is predominant.
l. If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.
m. If soil contains ≥30% plus No. 200 predominantly gravel, add "gravelly" to group name.
n. PI ≥4 and plots on or above "A" line.
o. PI <4 or plots below "A" line.
p. PI plots on or above "A" line.
q. PI plots below "A" line.



Laboratory Tests

DD	Dry density, pcf	OC	Organic content, %
WD	Wet density, pcf	S	Percent of saturation, %
MC	Natural moisture content, %	SG	Specific gravity
LL	Liqiuid limit, %	C	Cohesion, psf
PL	Plastic limit, %	∅	Angle of internal friction
PI	Plasticity index, %	qu	Unconfined compressive strength, psf
P200	% passing 200 sieve	qp	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders	over 12"
Cobbles	3" to 12"
Gravel	
Coarse	3/4" to 3"
Fine	No. 4 to 3/4"
Sand	
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Silt	< No. 200, PI < 4 or below "A" line
Clay	< No. 200, PI ≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose	0 to 4 BPF
Loose	5 to 10 BPF
Medium dense	11 to 30 BPF
Dense	31 to 50 BPF
Very dense	over 50 BPF

Consistency of Cohesive Soils

Very soft	0 to 1 BPF
Soft	2 to 3 BPF
Rather soft	4 to 5 BPF
Medium	6 to 8 BPF
Rather stiff	9 to 12 BPF
Stiff	13 to 16 BPF
Very stiff	17 to 30 BPF
Hard	over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers unless noted otherwise, Jetting water was used to clean out auger prior to sampling only where indicated on logs. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous-flight, solid-stem augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface and are, therefore, somewhat approximate. Power auger borings are designated by the prefix "B."

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn. Hand auger borings are indicated by the prefix "H."

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

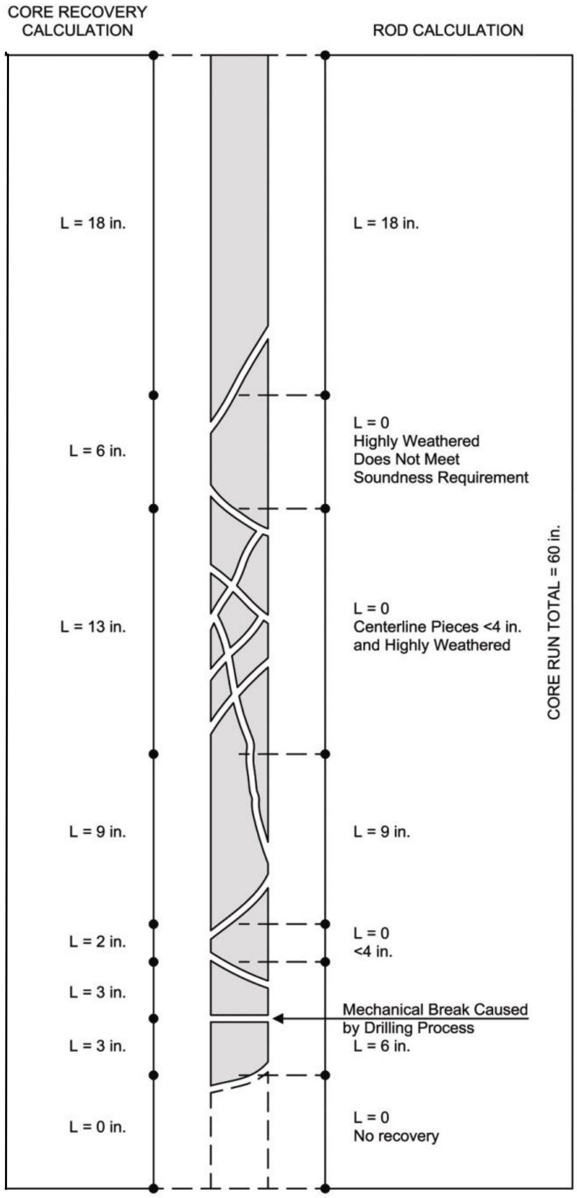
TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

BRAUN INTERTEC

Descriptive Terminology of Rock

Based on U.S. Army Corps of Engineers EM 1110-1-2908



Example Calculations

Core Recovery, CR = $\dfrac{\text{Total length of rock recovered}}{\text{Total core run length}}$

Example: $CR = \dfrac{(18 + 6 + 13 + 9 + 2 + 3 + 3)}{(60)}$

$CR = 90\%$

RQD = $\dfrac{\text{Sum of sound pieces longer than 4 inches}}{\text{Total core run length}}$

RQD Percent	Rock Quality
<25	very poor
25 < 50	poor
50 < 75	fair
75 < 90	good
90 < 100	excellent

Example: $RQD = \dfrac{(18 + 9 + 4 + 6)}{(60)}$

$RQD = 62\%$

Weathering

Unweathered: No evidence of chemical or mechanical alteration.

Slightly weathered: Slight discoloration on surface, slight alteration along discontinuities, less than 10% of rock volume altered.

Moderately Weathered: Discoloration evident, surface pitted and altered with alteration penetrating well below rock surfaces, weathering halos evident, 10% to 50% of the rock altered.

Highly Weathered: Entire mass discolored, alteration pervading nearly all of the rock, with some pockets of slightly weathered rock noticeable, some mineral leached away.

Decomposed: Rock reduced to a soil consistency with relict rock texture, generally molded and crumbled by hand.

Hardness

Very soft:	Can be deformed by hand
Soft:	Can be scratched with a fingernail
Moderately hard:	Can be scratched easily with a knife
Hard:	Can be scratched with difficulty with a knife
Very hard:	Cannot be scratched with a knife

Texture

Sedimentary Rocks:	Grain Size
Coarse grained	2 – 5 mm
Medium grained	0.4 – 2 mm
Fine grained	0.1 – 0.4 mm
Very fine grained	< 0.1 mm

Igneous and Metamorphic Rocks:	
Coarse grained	5 mm
Medium grained	1 – 5 mm
Fine grained	0.1 – 1 mm
Aphanitic	< 0.1 mm

Thickness of Bedding

Massive:	3 ft. thick or greater
Thick bedded:	1 to 3 ft. thick
Medium bedded:	4 in. to 1 ft. thick
Thin bedded:	4 in. thick or less

Degree of Fracturing (Jointing)

Unfractured:	Fracture spacing 6 ft. or more
Slightly fractured:	Fracture spacing 2 to 6 ft.
Moderately fractured:	Fracture spacing 8 in. to 2 ft.
Highly fractured:	Fracture spacing 2 in. to 8 in.
Intensely fractured:	Fracture spacing 2 in. or less